US Army Corps
of Engineers
North Central Division

Great Lakes Update

No. 103

February 2, 1994

Guide to The Monthly Water Level Bulletin

The Corps of Engineers has been publishing a *Monthly Bulletin of Lake Levels for the Great Lakes* since 1952. In the spirit of improving this publication, changes have been made over time to both its format and presentation. This month several significant modifications are being instituted. As such, this *Great Lakes Update* is being devoted to giving a general overview of the information currently being presented, and the rationale for the changes. It is hoped that this information will make the bulletin easier to understand and more useful to the reader.

An Overview

For each lake the bulletin provides a graphical representation of water levels. These plots, or hydrographs, show the water levels of the lakes from a number of different perspectives (Figure 1). Recent levels are plotted as a solid red line. Depending on the month of the bulletin, as few as 12 and as many as 24 months of recent levels may be presented. These are shown against a background of

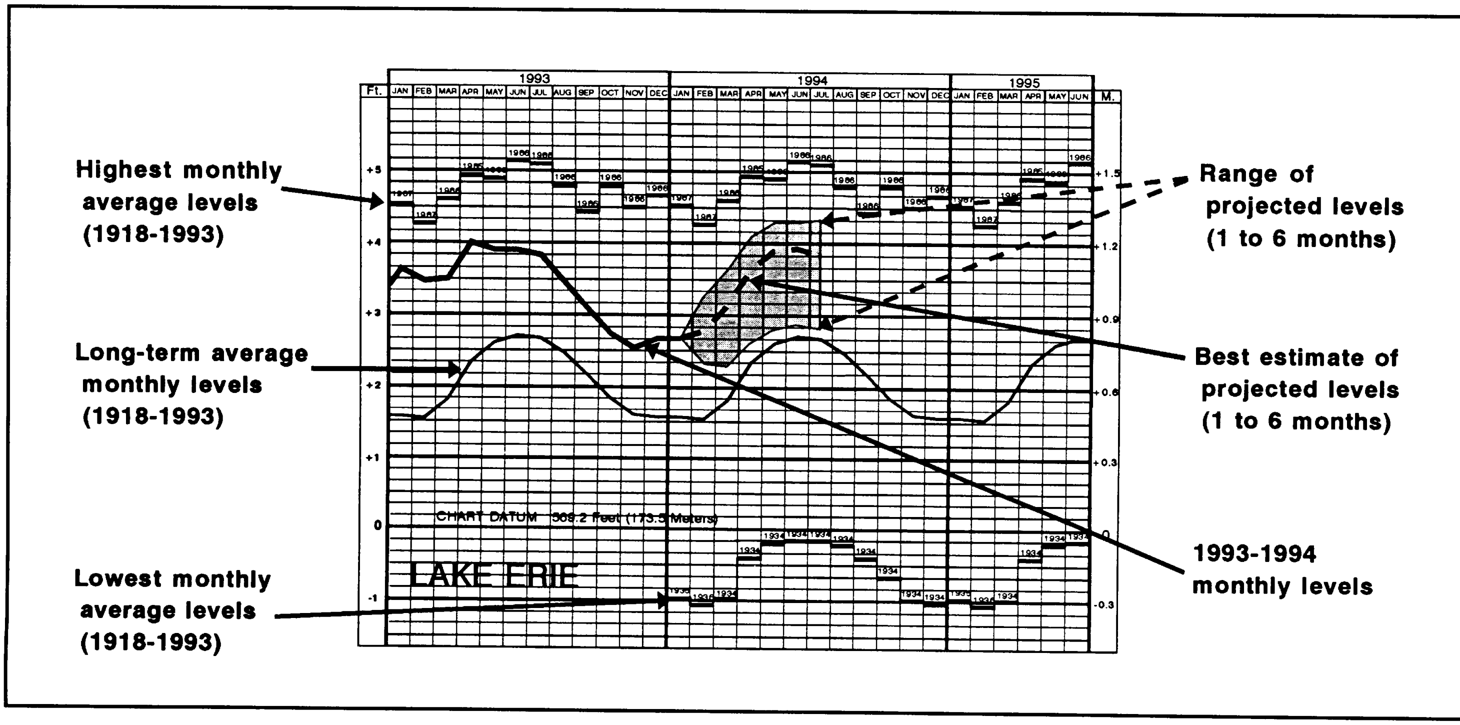

Figure 1. Sample Hydrograph, Excerpt from Monthly Bulletin

historical water level information (in blue), which includes the long-term average monthly levels of the lake, and the highest and lowest monthly average for each month, along with the years in which they occurred. Finally, projections are given for water levels for six months into the future (dashed red line and shaded red area). All levels on the bulletin represent still water, a water surface that is undisturbed by wind and waves. Information on storm rises is discussed later in this article, and beginning this month, will be provided in a table included in the *Great Lakes Update*.

Beginning with this month's bulletin, changes were made relative to the water level information presented, and how the range of projected levels is determined. These changes are described in some detail later in this article.

The water levels on the graphs are plotted relative to the Chart Datum for each lake. Chart Datum is a vertical plane to which navigation chart information, such as depths and Federal navigation improvements, are referred. Chart Datum is also known as Low Water Datum. There is a distinct Chart Datum for each lake. These datum planes have fixed elevations relative to the International Great Lakes Datum 1985 (IGLD 1985). The IGLD 1985 has its zero base at Rimouski, Quebec near the mouth of the St. Lawrence River (approximately sea level).

The grid upon which the water levels are plotted has a scale in feet to the left, and in meters to the right. The major divisions are every 1 foot (0.3 meter). The grid is further divided such that each of the small increments is 2 inches (0.05 meter).

The table of water levels in the lower right corner of the bulletin presents the average water level for the month just past. These levels are considered provisional at the time the bulletin is published, and may be subject to change. If changes occur, they are based on official gaging records and are generally small. For comparative purposes, historic information for the same month is also provided on this table. This includes the level of a year ago, the century's highest (maximum) and lowest (minimum) monthly averages for that month and the years they occurred, and the long-term average for that month. The long-term average is computed from data compiled for the period 1918-1992. The maxima, minima and long-term averages in this table are the same as those shown on the graphs. All the water level data in this table are given in feet and meters, and are referenced to IGLD 1985. To get the numbers plotted on the hydrographs, subtract the Chart Datum elevations for the corresponding lake from the numbers in the table.

A bulletin similar to the Corps' is published in Canada. To ensure uniformity, the vital information provided in the two bulletins, including the water level forecast, is the same, and is coordinated under th auspices of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. This committee was established in 1952 to determine and maintain mutually agreed upon data for the Great Lakes, ranging from water supplies and lake outflows, to drainage basin areas and lake volumes.

More details on where the information presented in the bulletin comes from and what it means are given in the following paragraphs.

Historic Lake Levels

The water levels for past months, and historic long-term average, maximum and minimum levels are now determined based on a network of water level gages. Each of the Great Lakes has a number of water levels gages located around its perimeter. Many of the gages in the U.S. have been recording since 1900, and some for more than 100 years.

Until this month, the historic levels presented in the bulletin were referenced to the master gage on each lake. When the Monthly Bulletin was initiated over 40 years ago, a single gage was selected to represent the level of each lake. Selection was based upon the longevity of the gage record, geographic location, and accessibility and permanence of the gage house. These so called "master gages" formed the bases for referencing chart depths and dredging associated with the Corps' navigation maintenance missions. These gages are located as follows:

Lake Superior - Marquette, MI
Lakes Michigan-Huron - Harbor Beach, MI
Lake St. Clair - St. Clair Shores, MI
Lake Erie - Fairport, OH
Lake Ontario - Oswego, NY

Although several of the gages listed above are replacements for the original master gage, the historic longevity of water level information has been maintained by correlating and combining data between the old and new gages.

There are a number of factors that may make water levels recorded at a single gage questionable for representing the overall level of the lake. On a short term basis (days, weeks and months), winds and storms can cause significant rises or falls in levels at different points on a lake, with no corresponding change in the volume of water. Over long periods of time (years), a phenomenon known as crustal movement also has a significant effect on the vertical datum planes to which water levels are referenced.

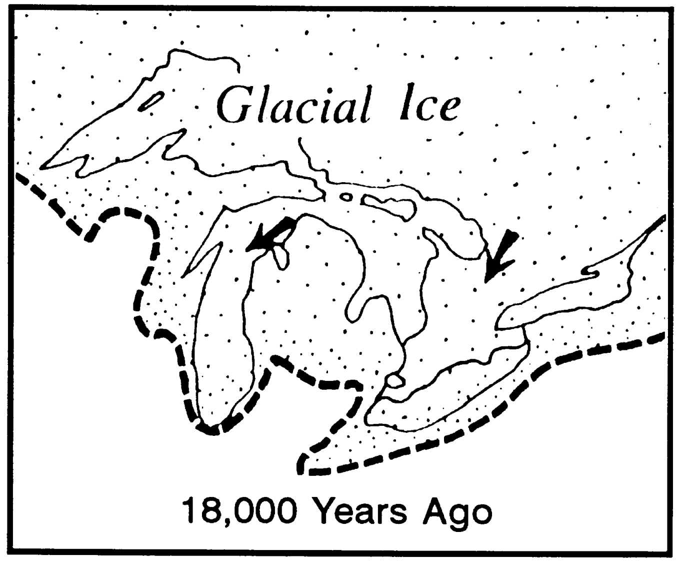

Figure 2. Extent of last glacial stage.

Present crustal movement in the Great Lakes region is the result of the natural rebound of the earth's crust from the substantial weight of the glaciers which covered the region 18,000 year ago (Figure 2). Because the force pushing down on the crust was less near the edges of the ice mass than near the center, the rate of rebound varies appreciably across the Great Lakes basin. Higher rates of rebound are occurring in the northern reaches of the basin, with some subsidence in the southwestern region (Figure 3).

So how does this affect water levels? First, it must be noted that water levels are measured in reference to some established vertical plane.

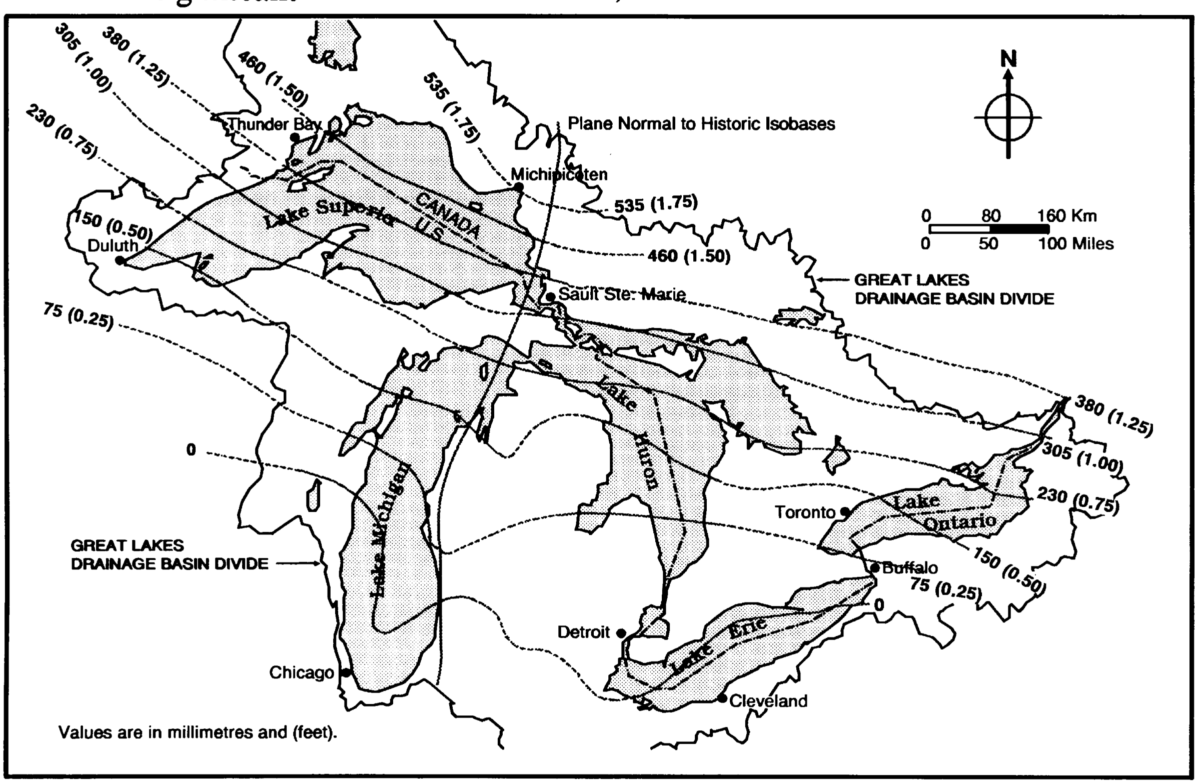

Figure 3. Vertical movement rates per century for the Great Lakes Basin.
(Adapted from Clark and Persoage, 1970, Larsen 1987)

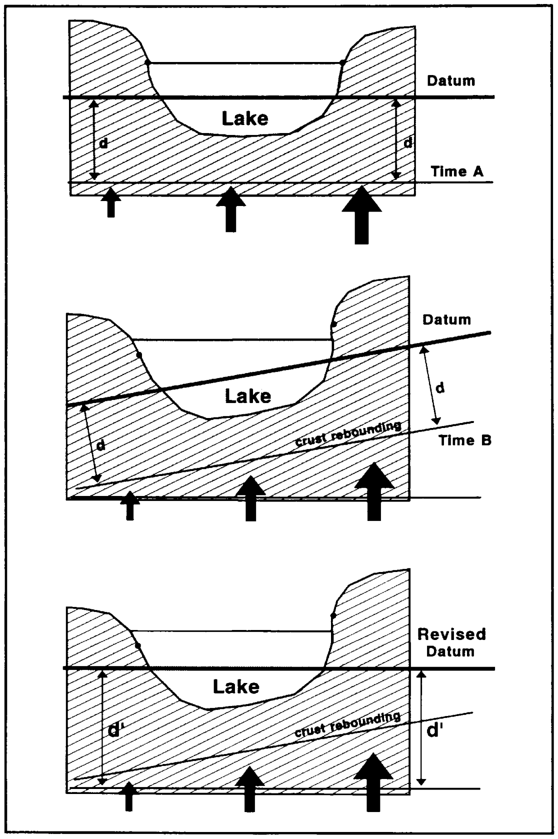

Figure 4. Crustal Rebound and Effect on Datum Plane.

When this plane of reference, or datum, is selected it is essentially parallel to the still surface of the lakes. As the crust moves so does this plane of reference. Over time, as the datum plane tips, gages around a lake soon begin to record different levels for the same still lake surface. Figure 4 illustrates this process. To correct for this phenomenon, the vertical datum to which Great Lakes water levels are referenced is periodically revised. The revision of the International Great Lakes Datum from IGLD 1955 to the present IGLD 1985 was the major topic of Update Letter No. 76, dated November 4, 1991. Elevations assigned relative to the new datum were such that, at the time the revision took place, all the gages on a lake recorded essentially the same level for the still surface of the lakes.

Adjustment of the datum planes, however, does not remove the difference between recorded water levels from gage to gage around the lake that is shown in the historic record. Figure 5 shows a plot of the difference between the levels recorded at Duluth, MN and Michipicoten, Ontario. The difference between these levels is near zero in 1985. This is because the gage records are referenced to IGLD 1985, and in the epoch year of this datum all the gages on Lake Superior recorded the same levels. (If levels referenced to IGLD 1955 were used, the differences would be near zero in 1955, but the trend of the line would be the same.)

What this all means is that a single water level gage cannot always represent th overall level of a lake. An average of levels recorded at many gages, evenly distributed around a lake will give a better representation of the level of the lake. This philosophy is now being incorporated into the Monthly Bulletin. Because relatively few gages were in operation prior to 1918, the long-term averages, maxima and minima now being used are based on the period 1918 to the present. The locations of the gages used to determine the monthly average lake levels being displayed on this and future bulletins are shown on Figure 6.

Forecasting Lake Levels

Projections of water levels are based on forecasting the amount of water the lakes will receive in coming months (water supply). Water comes to the lakes via precipitation

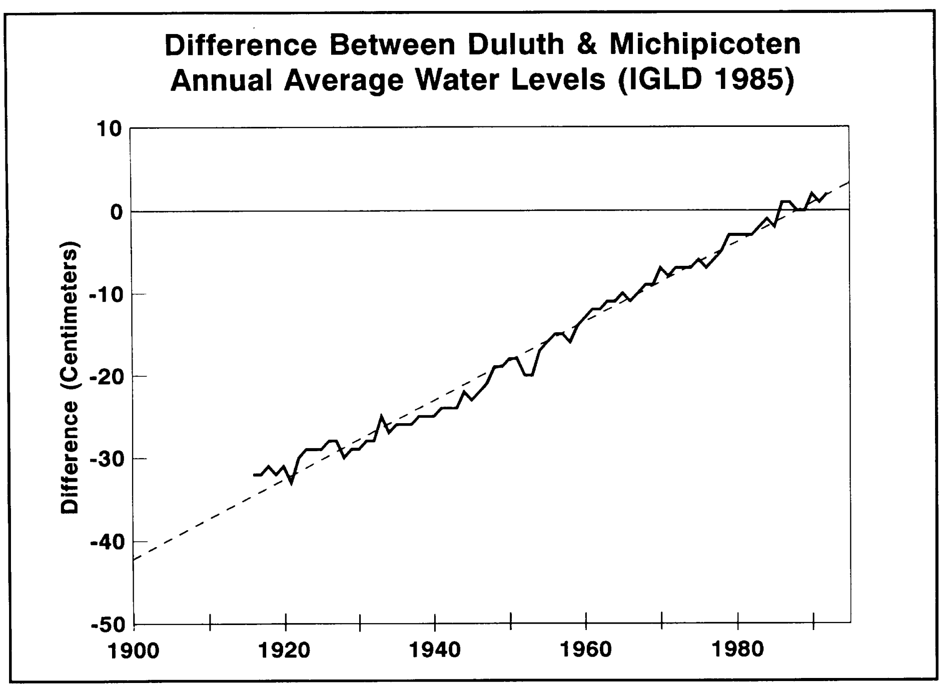

Figure 5.

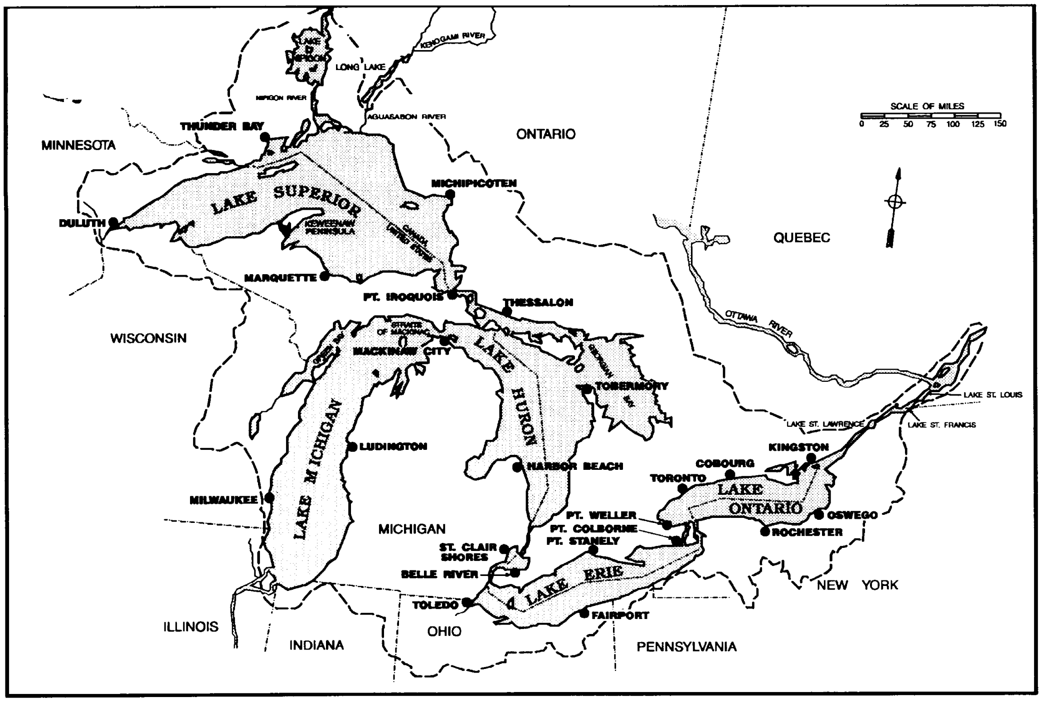

Figure 6. Water Level Gages Used to Determine Average Lake Levels.

on the water surface, runoff from the land portion of the asin, and inflow from the upstream lake. Water is also being lost from the lake via evaporation and outflow to the next lake. The fluctuation of water levels is directly related to the amount of precipitation in the form of rain and snow a lake basin receives, as well as the air temperature.

Since trying to project future water levels is like trying to predict the weather, there is a limit to how far into the future water level forecasts can reasonably be made. Also, just as there is a high degree of variability in weather forecast accuracy, water levels can vary widely from what may be predicted.

The bulletin presents a forecast of water levels six months into the future. The projections are for still lake levels, and make no allowances for local rises or falls that may take place as a result of storms or wave action. Forecasts are presented in two forms (Figure 1): a line (dashed red) giving our best estimate, and a range of additional possibilities (shaded red).

Starting with this bulletin the upper and lower boundaries of the forecast represent the possible range of levels that could occur if a lake were to receive water supplies much above or much below the averages usually expected each month. The series of supplies used are based on actual past water supply records, and represent very wet and very dry water supply conditions. Previous Monthly Bulletins defined the range of possible levels based on an analysis of the variability and accuracy of past forecasts. This resulted in a range of levels that was always evenly distributed around the best estimate line.

The best estimate of possible levels is based primarily on the existing conditions in the drainage basin and on forecasts of precipitation one to three months into the future. The precipitation and temperature outlooks are provided by the National Weather Service. The best estimate may not fall in the middle of the range of possible levels. If the best estimate anticipates water supplies greater than average, water levels may be expected to be in the upper portion of the forecast range, and vice versa.

Forecasting is more than a science, it is also an art. The most important tool available to forecast water levels is weather predictions. Presently, extreme conditions such as extended droughts or near-record precipitation cannot be accurately predicted. It is occurrences such as these that have led to the extreme water levels previously recorded in the Great Lakes region. Although not perfect, the Monthly Bulletin performs a beneficial service for the Great Lakes community, and will be improved as advances in long-range weather forecasting occur.

New Addition to the Update

As previously noted, the forecast of water levels presented on the Monthly Bulletin is for still or undisturbed water levels. No

Table 1

Possible Storm Induced Rises (in feet) at Key Locations on the Great Lakes
April 1994

	Degrees of Possibility				
	20%	10%	3%	2%	1%
LAKE SUPERIOR					
Duluth	0.8	0.9	1.1	1.2	1.3
Grand Marais	0.6	0.7	0.9	1.1	1.2
Marquette	0.8	0.9	1.1	1.3	1.4
Ontonagon	0.8	1.3	2.1	2.8	3.6
Point Iroquois	0.9	1.0	1.2	1.4	1.6
Two Harbors	0.6	0.7	0.9	0.9	1.0
LAKE MICHIGAN					
Calumet Harbor	1.5	1.7	2.0	2.1	2.3
Green Bay	2.1	2.5	3.1	3.5	3.9
Holland	0.9	1.0	1.2	1.3	1.4
Kewaunee	0.8	0.9	1.0	1.1	1.2
Ludington	0.9	1.0	1.1	1.2	1.3
Milwaukee	1.0	1.1	1.2	1.3	1.4
Port Inland	1.1	1.3	1.5	1.7	1.8
Sturgeon Bay	0.9	1.0	1.1	1.2	1.3
LAKE HURON					
Detour Village	0.5	0.6	0.7	0.8	0.8
Essexville	1.9	2.3	2.8	3.1	3.5
Harbor Beach	0.7	0.8	1.0	1.1	1.2
Harrisville	0.5	0.6	0.6	0.7	0.7
Lakeport	1.1	1.3	1.6	1.8	2.0
Mackinaw City	0.7	0.8	0.9	1.0	1.1
LAKE ST. CLAIR					
St. Clair Shores	0.6	0.7	1.0	1.1	1.3
LAKE ERIE *					
Barcelona	1.7	2.2	2.7	3.1	3.5
Buffalo	3.5	4.3	5.5	6.3	7.1
Cleveland	1.1	1.3	1.6	1.8	1.9
Erie	1.7	2.2	2.9	3.4	4.0
Fairport	0.9	1.1	1.4	1.6	1.9
Fermi Power Plant	2.0	2.5	3.0	3.5	3.9
Marblehead	1.5	1.8	2.2	2.4	2.7
Sturgeon Point	2.8	3.7	4.9	5.8	6.8
Toledo	2.7	3.3	4.0	4.5	5.1
LAKE ONTARIO					
Cape Vincent	0.8	0.9	1.1	1.2	1.4
Olcott	0.5	0.6	0.7	0.7	0.8
Oswego	0.7	0.8	0.9	1.0	1.1
Rochester	0.7	0.8	0.9	1.0	1.1

* The water surface of Lake Erie has the potential to tilt in strong winds, producing large differentials between the ends of the lake.

Note: The rises shown above, should they occur, would be in addition to the still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

Table 1

Possible Storm Induced Rises (in feet) at Key Locations on the Great Lakes February 1994

Degrees of Possibility

	20%	10%	3%	2%	1%
LAKE SUPERIOR					
Duluth	0.6	0.7	0.8	0.8	0.9
Grand Marais	0.4	0.5	0.6	0.6	0.7
Marquette	0.5	0.7	1.1	1.4	1.8
Ontonagon	0.3	0.4	0.5	0.6	0.7
Point Iroquois	0.8	0.9	1.0	1.1	1.2
Two Harbors	0.6	0.7	0.8	0.9	1.0
LAKE MICHIGAN					
Calumet Harbor	1.5	1.7	2.0	2.2	2.4
Green Bay	1.1	1.3	1.5	1.7	1.9
Holland	0.8	1.0	1.1	1.3	1.4
Kewaunee	0.6	0.7	0.8	0.9	1.0
Ludington	0.6	0.7	0.8	0.9	0.9
Milwaukee	0.9	1.0	1.2	1.3	1.4
Port Inland	0.9	1.1	1.3	1.4	1.6
Sturgeon Bay	0.6	0.9	1.3	1.7	2.1
LAKE HURON					
Detour Village	0.5	0.5	0.6	0.7	0.7
Essexville	1.1	1.4	1.8	2.0	2.3
Harbor Beach	0.5	0.6	0.9	1.2	1.5
Harrisville	0.4	0.5	0.6	0.7	0.7
Lakeport	1.1	1.5	2.0	2.5	3.0
Mackinaw City	0.6	0.8	0.9	1.0	1.1
LAKE ST. CLAIR					
St. Clair Shores	0.6	0.8	0.9	1.0	1.1
LAKE ERIE *					
Barcelona	1.8	2.5	3.4	4.1	4.8
Buffalo	3.2	4.0	5.1	5.9	6.7
Cleveland	1.0	1.3	1.7	2.0	2.3
Erie	1.5	2.0	2.7	3.3	3.9
Fairport	0.8	1.1	1.6	2.0	2.5
Fermi Power Plant	1.7	2.1	2.6	3.0	3.3
Marblehead	1.4	1.6	1.8	2.0	2.1
Sturgeon Point	2.6	3.2	3.8	4.3	4.8
Toledo	2.2	2.7	3.2	3.6	4.0
LAKE ONTARIO					
Cape Vincent	0.8	1.0	1.2	1.4	1.6
Olcott	0.4	0.5	0.7	0.8	1.0
Oswego	0.7	0.8	1.0	1.1	1.2
Rochester	0.5	0.6	0.9	1.0	1.2

* The water surface of Lake Erie has the potential to tilt in strong winds, producing large differentials between the ends of the lake.

Note: The rises shown above, should they occur, would be in addition to the still water levels indicated on the Monthly Bulletin. Values of wave runup are not provided in this table.

Great Lakes Basin Hydrology

During the month of January precipitation on each Great Lakes basin was above average, with the exception of the Lake Superior basin which was below average. For the year to date, precipitation is about 4% above average for the entire Great Lakes basin. The net supply of wate to each of the Great Lakes in January was below average. Table 2 lists January precipitation and water supply information for all of the Great Lak

In comparison to their long-term (1918-1993) averages, the January monthly mean water level of Lake Superior was 1.5 inches above average, Lakes Michigan-Huron, St. Clair and Erie were all 9 inches above average, and Lake Ontario was at its long-term average. Shoreline residents on Lakes Michigan-Huron, St. Clair and Erie are cautioned to continue to be alert to possible adverse weather conditions, as these could compound an already high lake level situation. Further information and advice will be provided by the Corps of Engineers should conditions worsen.

Table 2
Great Lakes Hydrology[1]

PRECIPITATION (INCHES)								
BASIN	JANUARY				YEAR-TO-DATE			
	1994[2]	Average (1900-1991)	Diff.	% of Average	1994[2]	Average (1900-1991)	Diff.	% of Average
Superior	1.8	2.0	-0.2	90	1.8	2.0	-0.2	90
Michigan-Huron	2.2	2.1	0.1	105	2.2	2.1	0.1	105
Erie	2.9	2.4	0.5	121	2.9	2.4	0.5	121
Ontario	2.7	2.6	0.1	104	2.7	2.6	0.1	104
Great Lakes	2.3	2.2	0.1	104	2.3	2.2	0.1	104

LAKE	JANUARY WATER SUPPLIES[3] (CFS)		JANUARY OUTFLOW[4] (CFS)	
	1994[2]	Average (1900-1989)	1994[2]	Average (1900-1989)
Superior	-30,000	-13,000	75,000	69,000
Michigan-Huron	50,000	53,000	169,000[5]	158,000
Erie	18,000	25,000	198,000[5]	192,000
Ontario	22,000	32,000	230,000	221,000

[1]Values (excluding averages) are based on preliminary computations.
[2]Estimated.
[3]Negative water supply denotes evaporation from lake exceeded runoff from local basin.
[4]Does not include diversions.
[5]Reflects effects of ice/weed retardation in the connecting channels.

CFS = cubic feet per second.

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